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Diseases, and Insect and Other Pests, of the Field Bean in New York

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DISEASES, AND INSECT AND OTHER PESTS, OF THE FIELD BEAN IN NEW YORK

In 1917, a laboratory for the investigation of diseases and pests of the bean, and for the breeding of improved varieties, was established at Perry, New York. This investigation was the outcome of a steady decrease in yield of the bean crop during the ten years previous, and of several years of almost total failure in certain sections of the State. The work at the laboratory was conducted by an entomologist, a plant breeder, and a plant pathologist. In 1921, the laboratory at Perry was discontinued, but certain phases of the work were carried on at the New York State College of Agriculture at Cornell University.

This bulletin, in the main, is a result of these investigations. The first part deals primarily with the diseases of beans as they occur in the dry-shell-bean districts in New York State. On the whole, the information given is also applicable to the snap, or garden, beans in any of the limited sections of this State where these are grown. The second part of the bulletin deals in a similar manner with the insect and other pests of the bean crop.

BEAN DISEASES IN NEW YORK

WALTER H. BURKHOLDER

During the past fifteen years or more, the bean industry in New York State has been threatened at various time by several of the diseases that affect this crop. Never has any one disease been general thruout the entire bean-growing section, or upon all the commercial-grown varieties, but each disease has affected seriously a certain section or variety. For example, ten years ago the mosaic was severe upon the pea beans, and many growers were forced to discontinue this variety until the Robust Pea bean, a variety grown in a limited area in Michigan and immune to the mosaic, was introduced. In Wyoming County, the root rots have proved very destructive in the section where marrows are grown, and at present the bacterial blights are so severe on the Red Kidney variety that only the prices for this bean have induced the farmer to continue growing it. Other diseases, as the anthracnose, may occur on any variety and in any locality during any seasons when the weather is favorable for the disease, and when little care is taken in the selection and purchase of seed. To control these diseases the main policy of the Perry Bean Laboratory was to endeavor to select or breed strains of our standard commercial varieties of field beans that are resistant to the various de-

structive diseases. This was undertaken thru the cooperation of the plant breeder and the plant pathologist. While this work, in the main, is still going on at Cornell, certain disease-resistant varieties have been placed on the New York market. These are the Wells' Red Kidney, the White Imperial, and the Perry Marrow, which are especially resistant to the anthracnose; also, a type of White Marrow, introduced from Nova Scotia, which is somewhat resistant to the same disease; and the Robust Pea bean, which is immune to the mosaic disease. The Robust Pea bean, frequently referred to as the Michigan Robust Pea bean, has shown also a certain amount of resistance to the bacterial blight.

The introduction into New York State of new bean varieties, especially those possessing resistance to disease, is a sound method of improving the industry, and one which should be furthered. Such introduction, however, should be handled thru adequate channels where the qualities of the beans can be tested. This seldom can be done by individuals or even seed companies. In the past, the introduction of certain varieties not thoroly tested has resulted in grave losses to the grower. An outstanding example of this was the Otenashi, a white bean with no advantages over the Robust and the disadvantage of being very susceptible to the mosaic. During the spread of this disease in 1931, the greater losses were in fields planted to this variety.

In the following discussion, an attempt has been made to point out the economic importance of the various diseases of the bean that occur in New York State; to give a description of their symptoms in order to distinguish them from one another; and to acquaint the grower with the various known methods of control. In doing this, several of the less important diseases also are described, since there might otherwise arise some difficulty in distinguishing them from some of the more important ones.

In pointing out methods of control, precautionary measures are emphasized, since it is practically impossible to eradicate a disease-causing organism (a pathogene) after it has once established itself in a bean-growing section. Nevertheless, even with this in mind, it is frequently difficult for the grower to realize the necessity of applying such measures when there is no disease in sight. This attitude, too, is furthered by the fact that few of the troubles occur on any one farm year after year in a destructive form. There is always the chance that weather conditions will be unfavorable for the development of the diseases. Thus diseases have been allowed to become generally more severe, year after year, until now they are menacing the bean industry of the State. And this again urges the production of disease-resistant varieties. In the meantime, what control measures we have should be applied.

A Descriptive Key to Bean Diseases

On the plant parts above ground

1. Areas on veins on under sides of leaves turn black; dark, circular, sunken spots appear on pods, and similar spots are found on the stems of the seedlings; most serious in rainy seasons.....**Anthracnose** (page 7)
2. Large, brown, dead areas form on the leaves; watery irregular spots appear on the pods, and these later turn reddish and become sunken; at times there is a rotting of the stem at the first joint.....**Bacterial blight** (page 11)
3. A tip-burning of the leaves and a dwarfing of the plant occur; also, a decided wilting of a part, or the whole, of the plant.....**Bacterial blight** (page 11)
4. Dwarfing, mottling, and crinkling of the leaves occur; in many instances, the plant grows bushy and remains green until frost; few or no pods set; found more generally on the pea and medium varieties of field beans.....**Mosaic** (page 17)
5. Small, powdery, brown pustules occur on the leaves, stems, and less frequently, on the pods; disease appears late in August.....**Rust** (page 25)
6. A rotting of the stems and the pods of the plant takes place, accompanied by a cottony growth, and small, black, hard bodies about ⅛ or ¼ inch in diameter are formed; disease occurs in rainy seasons, or in damp, shady places.....**Sclerotinia rot** (page 26)
7. Plants dwarfed; such varieties as the marrow and pea fail to vine; few pods produced; leaves turn yellow and drop prematurely; more severe in dry weather .....**Dry root rot** (page 21)

On the plant parts below ground

1. Taproot is at first red, but later becomes brown and dried; frequently a mat of surface roots produced; most severe in dry weather....**Dry root rot** (page 21)
2. Taproot reddish at first, but later coal-black lesions with a frosty appearance in wet weather form on roots; most severe on seedings and in cool weather.....**Black root rot** (page 24)
3. Brick-red, sunken blotches on lower stem and on taproot; seldom severe .....**Rhizoctonia blotch** (page 24)

THE ANTHRACNOSE

Possibly more attention has been given to the anthracnose than to any other disease of the bean. This is due, no doubt, to its wide-spread distribution. No matter where beans are grown, in small gardens or extensively, as a field crop, the anthracnose is likely to become severe when conditions are favorable for its development. In New York State, serious outbreaks of the disease do not occur oftener than every four or five years, and even then they are ordinarily limited to certain localities. The conditions that bring about these outbreaks are the rainy periods which are usually accompanied by alternate cool and warm temperature. During these periods, the disease may damage a crop to approximately 100 per cent.

Symptoms

On the seed. On the seed, the disease appears as irregular, discolored areas. The smaller areas, in many instances, are smooth and of a some-

what tawny brown, while the larger ones are raised, and black in color, with brownish borders. The small spots caused by the anthracnose are very difficult to distinguish from the bacterial-blight spots or the blemishes due to mold fungi.

PHOTO BY H. H. WHETZEL

FIGURE 1. THE ANTHRACNOSE DISEASE ON A YOUNG BEAN PLANT
Showing the lesions on the leaves and stalk

On the seedlings. Young seedlings from diseased seed may become severely affected. Large, black cankers appear on the cotyledons of affected plants, and these later develop pinkish centers. Similar black, oval lesions occur along the stems of the seedlings (figure 1), and in some instances these extend so far into the tissue that the entire plant is destroyed.

On the leaves. On the tender leaves of the seedlings, the anthracnose disease appears as scald spots, which frequently involve the entire leaf. On the veins of these leaves, especially on the underside, small black dashes may be observed (figure 1). On the older and more mature leaves, the disease appears only on the veins, causing a black, network appearance. Lesions rarely occur on the leaf tissue between the veins, but severely affected leaves turn yellow and drop.

On the pods. The most characteristic and striking symptom of the anthracnose appears on the pods (figure 2). Here the lesions are black, circular, and sunken. As in the lesions on the other parts of the plant, a pinkish center may be developed. Some of the young pods may be so severely infected that they will fail to develop. In other instances, but one or two spots may appear on the pod and will affect the seeds under them. If the anthracnose comes on late in the

PHOTO BY M. F. BARRUS

FIGURE 2. THE ANTHRACNOSE DISEASE ON BEAN PODS

season, it may not materially reduce the yield. It may, however, gain entrance into the seed, and thus become a serious factor in reducing the next year's crop.

Cause

The anthracnose of the bean is caused by the fungous pathogene *Colletotrichum lindemuthianum.* The life history of this organism is simple. With the germination of a seed containing the pathogene, a lesion appears on the cotyledon. In the center of this lesion, the fungus produces a mass of spores, and these spores serve to disseminate the pathogene thruout the field. Since these spores are held together by a gelatinous substance which is dissolved by water, a rain is essential for their dissemination. The spores, too, can germinate only in the presence of moisture. Rain may splash the spores from the lesion to the leaves and the stems of the plant, or to other plants, where further lesions are then produced. Animals or tillage instruments passing thru a bean field when there is dew or rain on the plants also spread the disease. The spores produced in these secondary lesions may infect the pods when they are formed. It is on the pods that the disease is most noticeable and causes the greatest amount of damage. The thread-like mycelium of the pathogene works its way thru the pod tissue and enters the seed. Here it may cause a spot, according to how deeply it penetrates and how much tissue is involved. Within the seed the organism passes the winter. When seeds thus infected are planted and germinate, the fungus again becomes active, provided the weather is sufficiently moist. This completes the life cycle.

Control

Many recommendations for the control of bean anthracnose have been advanced from time to time. No method entirely satisfactory from the standpoint of the grower, however, has been suggested. Seed treatment has not been found to be beneficial, as the fungus advances too far into the seed and is altogether too resistant to such strengths of chemicals and such degrees of heat as do not injure the seed itself.

Spraying is not practical where beans are grown on an extensive scale, since the bean plant is a rapid grower, and it would therefore be necessary to make numerous applications each year in order to keep the plants covered with the spray. Many of the field beans, too, are running types, which would be greatly injured by the spray machine. Furthermore, severe outbreaks of the disease occur not oftener than once in every five years, and to ward off this one outbreak, five years of spraying would be necessary, and the gain in yield would by no means pay for the numerous applications of spray. On this account, it is scarcely advisable to spray. Dusting also comes in the same category.

Disease-free seed. Possibly the most widely accepted method for the control of this disease is the selection of disease-free seed. This is based on the idea of using only healthy seed for planting, and thus eliminating the disease entirely from the field. It is known that the disease-producing fungus lives over winter in the seed, and that other methods of overwintering are very exceptional.

In obtaining a start of anthracnose-free seed, it is impossible to hand pick them, since many of the seed may be infected with the anthracnose fungus without showing a spot on the surface. It has been proved, however, that pods free from spots produce seeds free from the disease. It is readily seen that it is impossible to select a sufficient number of pods to plant a large field. It is possible, however, to select a large enough number to plant a seed plot of a size the grower desires, probably an acre. The seed from this acre can then be used the second year to plant the entire crop. Certain care should be taken of this seed plot, however. It should be from fifty to eighty rods removed from the general bean fields in order to escape contamination from them. Like any bean field, it should never be entered when dew or rain is on the leaves. Careful watch should be taken of the plot, and all diseased and off-type plants should be removed. This method of raising seeds on a seed plot planted with carefully selected seed should enable one to produce a sufficient amount of clean seed for general planting, and, as compared with spraying, requires considerably less time and work.

Disease-resistant varieties. Without doubt, the most satisfactory method of disease control is the use of disease-resistant varieties. Four varieties of beans with a high resistance to the anthracnose are now on the market. They are the Nova Scotia Marrow, the Perry Marrow, the Wells' Red Kidney, and the White Imperial.

The Nova Scotia Marrow is a large white bean introduced into New York State from Nova Scotia. In growth this bean is not indeterminate like the New York Marrow, but a bush, considerably smaller than the Red Kidneys. Its seed is very large and plump, and they mature from a week to ten days earlier than the ordinary Marrow. Altho the Nova Scotia Marrow has been on the New York Market for only approximately ten years, it already is difficult to obtain a pure stock of seed. It has been greatly mixed, either carelessly or perniciously with the New York Marrow. The mixture is readily detected when the plants are growing by the two distinct growth types.

THE BACTERIAL BLIGHT

The bacterial blight is characterized by numerous and varied types of symptoms. In many of its stages, the disease may be distinguished from some of the other diseases of the bean only by careful examination.

Certain symptoms, however, such as the lesions occuring on the leaves and on the pods, are characteristic, and it is these that, for the most part, occur in the fields and are described in literature.

The bacterial blight in New York State is found, year after year, in

FIGURE 3. BACTERIAL-BLIGHT LESIONS ON A BEAN LEAF

a large majority of the bean fields. Of the dry shell beans, the kidney varieties are the most susceptible.

Usual symptoms

On the leaves. The disease first appears on the leaflets, as small, wilted areas which are at first somewhat water-soaked. These enlarge, dry out, and assume a brown, papery appearance (figure 3). About the lesions there is a lighter, yellowish border. A single leaflet may contain a number of such spots of various sizes, which may finally coalesce and involve the entire green surface. During rainy and windy weather, these infected leaves may be whipped about and become very ragged. In a severe attack of the bacterial blight, an entire field may appear as if it had been fire swept. In less severe cases, the disease may develop only in small patches thruout the field.

On the stems. Reddish lesions may be found on the stems and stalks of the bean plant affected with the bacterial blight. These lesions are frequently in the form of dashes extending longitudinally with the stem. The most severe type of lesion occuring on the stalk, however, is the stem girdle. A reddish brown decay of the first and second nodes, or joints, takes place, which greatly weakens the plant. Thus, during a heavy wind storm, plants so affected may be blown over very readily. This type of symptom occurs not infrequently on the Red Kidney variety, and the writer has observed it to be severe on the Refugee Green Pod.

On the pods. On the pods, the disease may occur in small spots, or practically the entire pod may be affected. The lesions first appear as water-soaked spots, which later dry down to reddish, irregular, sunken areas (figure 4). Over these diseased spots there may be observed, in many instances, a yellowish encrustation of the dried bacteria.

On the pods, this disease may at times be confused with the anthracnose and the sun scald. The anthracnose spots are always circular, however, and as a rule darker and never water-soaked. On the other hand, it is more difficult to distinguish the bacterial blight from the sun scald. The sun scald occurs only on the surface of the pod exposed to the sun, and as a rule, with such field beans as the White Marrow and the Pea, it appears on the pod just over the seeds.

On the seed. On white seed, the disease occurs as yellow spots. In some instances these spots may appear about the size of a pin head, and be located at the place where the seed is attached to the pod. In other instances the lesions may involve the entire seed, causing it to shrink and become somewhat wrinkled. In these cases, it appears as if the seeds were coated with a yellow varnish. On colored seeds, the spots usually are brownish and frequently cannot be distinguished from the anthracnose spots.

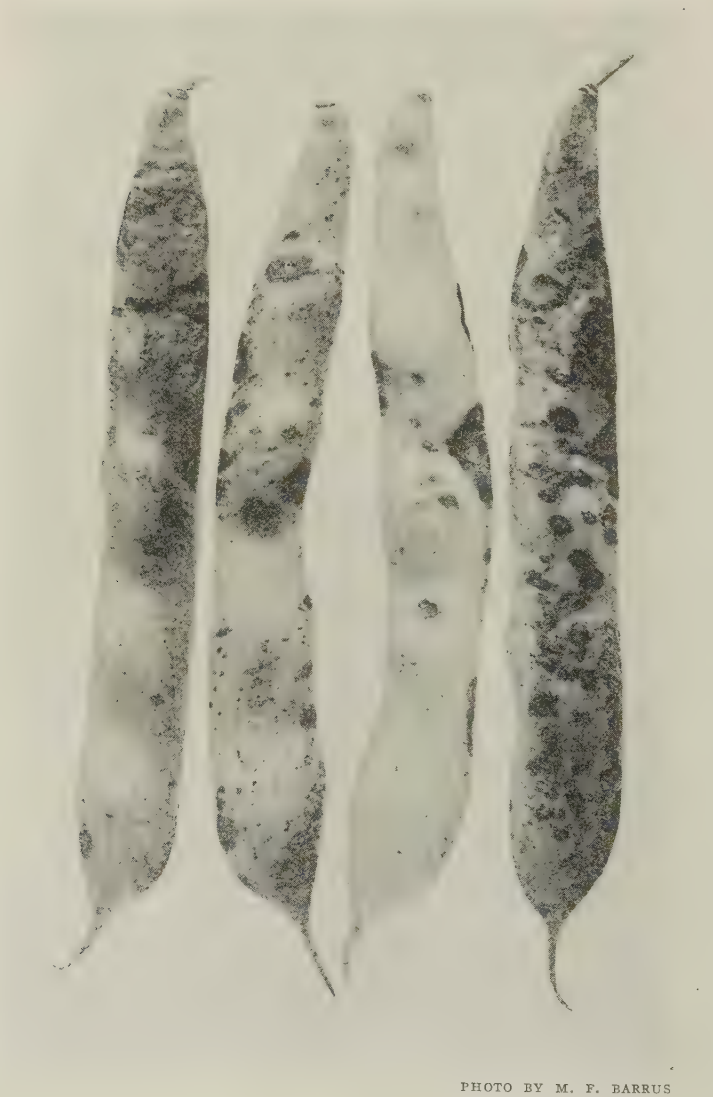


PHOTO BY M. F. BARRUS

FIGURE 4. LESIONS ON BEAN PODS DUE TO THE BACTERIAL BLIGHT

Unusual symptoms

On the seedlings. It not infrequently happens that a seed affected with the bacterial blight germinates and appears above ground with its growing tip injured or entirely destroyed (figure 5). Such young seedlings have been called *snakeheads*.[1] Under certain conditions, snake-

[1] See account of seed corn maggot, page 28.

Figure 5. Young seedlings affected with the bacterial blight

heads may send forth a new shoot and grow, but very few pods are produced on such plants. Another condition arising from diseased seeds is a mosaicking of the first two leaves, which is due to the disease appearing as water-soaked areas scattered over the leaf between the veins. At times the plant may outgrow the disease when it appears in this form, but more frequently the lesions which are usually considered more characteristic of the disease are subsequently produced on the growing plant.

The wilt. A wilting of the bean plant, due to the bacterial blight, may occur at any time from the seedling stage until the plant has produced mature pods (figure 6). Frequently no external lesions of the disease are found on plants affected in this manner. Seeds from the pods of wilted plants may show typical blight lesions, and may in turn produce diseased plants.

FIGURE 6. WILT OF A RED KIDNEY BEAN PLANT DUE TO THE BACTERIA IN THE WATER VESSELS

Some of the seeds were blighted, altho no lesions occurred on the pods

Cause

The cause of the bacterial blight of the bean is usually attributed to a bacterium known technically as *Phytomonas phaseoli*. Recently, however, it has been shown that there are at least six distinct bacterial organisms that may cause a blight. The symptoms are similar and from the growers standpoint they may be considered as one disease. While the organisms react differently to different environments, their life histories appear to be the same. The bacteria infect the seeds, where they may persist within the seed coat for several years. On the germination of the seed, the bacteria again become active, and invade the seedling. They may do this in two ways. The bacteria may be carried by insects or splashed by rain from the cotyledons to the leaves and stems of the plant, and there cause local lesions; or the organisms may enter the stem from the cotyledons and thence proceed thru the water vessels to various parts of the plant. The wilting of the bean plant already described is due to these bacteria being in the water vessels. In the fields, the bacteria are disseminated by rain splashing them from one plant to another, or they may be carried by insects. During the season of 1919, the plants in fields where there were large numbers of grasshoppers were nearly all diseased. With the infection of the seed by the bacteria, either thru

the vessels or from spots on the pods, the life cycle of the organism is completed.

Control

Selection of seed. The best method of control for the bacterial blight of the bean is the use of disease-free seed. If a grower has a field of beans free from this disease, he should save it for seed rather than buy from the open market. If the grower has a seed plot, as suggested among the control measures for the anthracnose of the bean, all blighted plants should be removed and burned.

The use of varieties resistant to diseases is being recommended as a control for many plant diseases. At the Perry Bean Laboratory, approximately 150 varieties were tested for resistance to the bacterial blight. No variety, however, was found with any great resistance. The Robust Pea bean seed at present appears to be relatively free from the blight. This strain, too, shows a certain amount of resistance to the disease.

Recently, it has been found that Red Kidneys grown in certain parts of California are entirely free from the bacterial blights, and that the seeds brought in have produced healthy fields the first year. Ultimately they become contaminated. The length of time for this to happen would depend, no doubt, on the care taken of the seed. If planted next to or near a field of state-grown seed, they would probably become infected very quickly. If isolated in the field from all other beans, it would be safe to use them for seed, as long as no disease appeared in the field.

Seed treatment. Soaking seed from eighteen to twenty minutes in a 1-50 benetol, or a 1-1000 corrosive-sublimate, solution will decrease the number of diseased seedlings under conditions existing in Louisiana. This method, however, has never been tried in New York State. Soaking the bean seeds, even for a short time, frequently injures the germination, and therefore great care should be used in treating them unless they can be dried readily after the treatment. Hot-air treatment is of no benefit, as the blight bacteria are more resistant to dry heat than is the bean seed.

Cultural measures. Altho there is no good evidence that the blight bacteria will live over winter in bean-straw manure, it is possibly best not to put this fertilizer on land which is to be planted to beans.

THE MOSAIC DISEASE

Perhaps the most recent disease to cause serious damage to the bean industry of New York State is the mosaic. This disease first appeared as a menace to the crop in 1916, and by 1918 many farmers had discontinued their bean growing on account of it. The most susceptible of the dry-shell varieties are the White Pea, the Otenashi, and the medium-sized white beans, as the Burlingame and the Blue Pod Medium. The White

Marrow and the Yellow Eye are more or less resistant, while the Kidney is not damaged to any extent when it does become infected. The reaction of the garden varieties to this disease has not been carefully worked out. It is known, however, that they vary considerably in their behavior when infected by mosaic and that the Refugee types are very severely affected.

Symptoms

The most striking symptoms of the disease occur on the leaves of the bean, and in character the disease is more or less like the mosaics on other plants. The younger leaves are more particularly affected. They are usually smaller, cupped downwards, and, when held to the light, show various areas of darker and lighter green (figure 7). The smaller veins are seldom evident on the upper side of the leaf, and cupped swellings, dark green in color, are sometimes found on this surface. Affected plants are off-color, being a paler green. Later in the season such a plant may become yellow or bronze color, but more frequently the plants stay green until frost. In the Pea beans, and in certain other less important varieties, no pods are set after infection once takes place (figure 8). Thus if the disease does not appear until after the middle of August, there is very little reduction in yield. On the other hand, if the mosaic develops before the normal podding stage of the bean plant, a considerable decrease in yield may result. When this happens, fields are frequently plowed under, since the amount of seed produced is not sufficient to pay for harvesting.

When the mosaic appears in a field early in the season, a large proportion of the plants, as a rule, become infected, and since no distinct lesions appear, the grower is not likely to recognize the disease. Moreover, when no pods are produced, the cause is likely to be attributed to some weather conditions, for it is known that hot, dry weather at blossoming time will cause the blossoms to drop, and thereby will reduce the crop.

Cause

The cause of the mosaic disease of the bean is not known, but a number of points have been discovered concerning the nature of the cause. When a leaf on a healthy bean plant is rubbed with a leaf affected with the mosaic until the tissue is broken, the healthy plant will become diseased within from eight to eighteen days. It appears that a virus is transmitted from the diseased to the healthy individual, which indicates that probably the mosaic is a germ disease. The mosaic virus is known to be carried in the field from one plant to another by aphids and, with further study, other insects undoubtedly will be found which are able to transmit it. It also lives from one season to another in the bean seed.

Control

Cultural measures, spraying, dusting, seed treatment, or the selection of seed from healthy plants when the mosaic is present in a field, will not control the disease. But one safe method is known, and that is the use of varieties resistant to this disease. As already stated, the Pea bean is the most susceptible of the dry shelled beans grown in New York State. It is also one of the most widely known varieties. A certain strain of the Pea bean, however, known as the Robust, is immune to the mosaic. Be-

FIGURE 7. A BEAN LEAF AFFECTED WITH THE MOSIAC DISEASE
This shows the cupping of the leaves, and the characteristic light and dark areas

FIGURE 8. A PEA BEAN PLANT AFFECTED WITH THE MOSIAC DISEASE
Showing the small leaves and the absence of pods

sides this, it is the highest yielding variety that has been tested by the Department of Plant Breeding at Cornell. For these two reasons, the use of this variety is urged. The Otenashi, another white bean and one introduced recently from the Orient, is a very susceptible variety.

The Red Kidney, the White Marrow, and the Yellow Eye are three other widely known field beans in western New York. These varieties are not injured to any extent by the mosaic, and may be grown without fear of this disease. The reaction of the garden varieties to the mosaic has not been carefully examined, but it is known that many of them will produce an abundance of pods, even tho infected with the disease.

THE DRY ROOT ROT

The dry root rot is very common in western New York, especially where beans have been grown extensively for the past thirty years or more. The dry root rot may be found each year, but the more serious effects of the disease are apparent during the summers having a dry July and August During such seasons, this disease has been known to reduce the crop approximately 50 per cent.

Symptoms

Below ground. The first symptom of the disease appears on the bean plant a week or two after germination. At this time, a slight reddish discoloration may be seen on the taproot of the seedling. The color later deepens, and reddish dashes may extend up to the surface of the ground. As the disease progresses, the lower part of the taproot becomes dry and brownish (figure 9). Frequently cracks may be observed extending lengthwise of the stem. With the lower part of the root dead, the plant sends forth a mass of surface roots above the diseased area and sometimes these surface roots also become diseased. Thus with a greatly reduced root system, the bean plant is unable to produce many pods unless there is an abundance of moisture in the soil.

Above ground. Symptoms of the disease above ground as a rule are not observed during the first month or so of growth of the bean plant. The affected plants are somewhat dwarfed, but this is not generally noticeable except in comparison with healthy individuals. About podding time, however, the effect of the root rot on the plant parts above ground becomes more evident. If it is during a dry period, the severest symptoms may appear (figure 9). Running types of beans, such as the White Marrow, Medium, and Pea, may fail to vine (figure 10). Few pods form, and the few that do are not well filled. On the other hand, during wet seasons the surface roots left on the diseased plants may be able to supply the upper part of the plant with sufficient amounts of nutrients and water to produce a good yield.

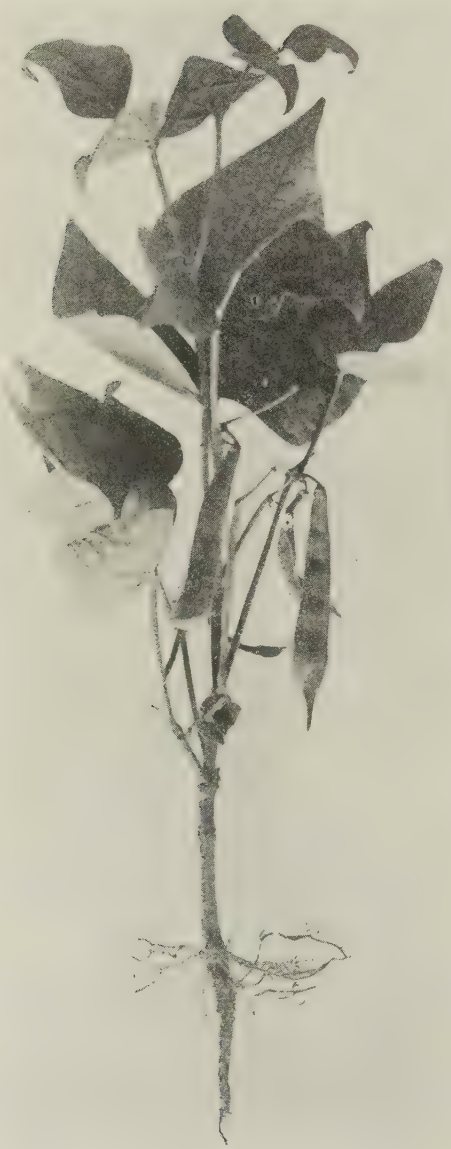


FIGURE 9. THE EFFECT OF THE DRY ROOT ROT ON A WHITE MARROW BEAN PLANT

The diseased plant has failed to vine. Also, the pods are few in number, and are poorly filled

Cause

The cause of the dry root rot of the bean is a fungus known as *Fusarium martii phaseoli*. This fungus is a soil-inhabiting organism, and may live for many years in the fields, even in the absence of the bean plant. It does not attack the other plants grown in a rotation nor the common weeds. When beans are planted again in such a field, the organisms soon infect the roots of the plants, and cause the symptoms already described. The growing of beans continuously, or even in short rotations, in a field appears to multiply the organism in the soil.

The fungus may live over winter in the soil or in the compost heap where bean straw has been fed. Manure thus infested may be carried to new fields not previously infested, or it may be returned to old fields where the soil becomes even more thoroly contaminated. The fungus is also spread from one field to another by washing during heavy rains, and is carried on the feet of animals and on tillage tools.

Control

No very satisfactory method of control has yet been developed for this disease. Certain precautionary measures may be taken, however, which have proved beneficial in many instances.

Figure 10. A field of white marrow beans affected with the dry root rot

The rows are 28 inches apart. Healthy plants would cover the ground

Selection of land. Beans should not be planted on fields which are known to be thoroughly infested with the disease-producing fungus. Land which has never, or but seldom, been planted in beans is satisfactory. Manure containing bean straw should not be applied to fields that are free from the pathogene, nor on land on which beans are to be planted. Where long rotations are followed, the disease is seldom so severe. Short rotations increase the trouble.

Cultural methods. Shallow cultivation is especially recommended in fields affected by the dry root rot. This is advisable because the surface roots are the only ones supplying the diseased plants with food and water, and these, therefore, should be disturbed as little as possible.

Soil treatment. The application of various fungicides to the soil to eradicate the pathogene has not proved beneficial. Sufficient amounts cannot be applied without injury to the bean plant. Also, the severity of the disease does not vary with soil acidity or alkalinity within the ranges of bean growing.

Disease-resistant varieties. There are no root-rot-resistant varieties of beans on the market at present. Certain variations in susceptibility have been noted, however. The Blue Pod Medium and the Robust tolerate the disease fairly well, but the Blue Pod Medium cannot be recommended because of its susceptibility to the mosaic. The Yellow Eye bean has proved

to be very susceptible to the root rot. At the Perry Bean Laboratory, however, a certain non-commercial variety, known as the Flat Marrow, was found to be very resistant to this disease. This resistant bean has been crossed with the common commercial varieties of the dry shelled beans, and the results are promising.

OTHER ROOT ROTS

Two other root diseases of less economic importance occur on the bean plant. They are the black root rot, caused by the fungus *Thielavia basicola,* and the Rhizoctonia blotch.

The black root rot

In New York State, the black root rot has been observed only in Wyoming and Livingston Counties. Here it occurs early in the season, on the seedlings and on young plants. Reddish discolorations, similar to those of the dry root rot, appear on the taproot. Coal-black lesions later arise in these discolored areas, and may encircle the entire taproot and destroy many of the lateral rootlets. During a wet period, a frosty appearance frequently covers these black spots.

As the season progresses and the soil becomes warmer, the bean plants may outgrow the disease. New roots are sent forth which are not attacked by the fungus. Thus it is evident that the black root rot is primarily a disease of cool weather, and cannot withstand the warm months of July and August in New York.

Since the disease causes but slight damage to the bean crop, little consideration has been given to its control. The precautionary measures recommended for the dry root rot should also serve for the black root rot. Long rotations to eliminate the pathogene would not be feasible, since it is able to attack many of the common plants, such as clover, alfalfa, peas, and the like.

The Rhizoctonia blotch

The fungus *Rhizoctonia* attacks a still greater number of plants than does *Thielavia basicola.* On the bean plant, however, the damage is slight, and may be passed over with only a few words. Brick-red lesions, irregular in shape and sunken, occur on the taproot, on the bean stem near the surface of the ground, and on pods in contact with the ground. These are observed more frequently during the early part of the growing season, when the stem tissue is tender. Altho quite general thruout the bean section, an appreciable loss has never been observed to occur because of this disease.

RUST

The rust of beans is primarily a disease of warm climates, and is especially destructive in the Southern States. In New York State it is a disease of no great importance. It has never been observed to appear before the last of August, and by then the plants are so far matured that little injury is sustained. Attention should be given to it here, however, since the average grower and the seed catalogs are likely to call such diseases as the anthracnose, the bacterial blight, and such weather injuries as the

PHOTO BY H. H. WHETZEL.

FIGURE 11. BEAN LEAVES AFFECTED WITH THE RUST

sun scald, by the name of *rust*. Thus the disease may be mistaken, and the methods of control be confused.

The rust spots are found chiefly on the leaves of the bean plant. In appearance, they are small pustules about the size of a pin head and are on both the upper and lower surfaces of the leaf. When mature, they break open and discharge a brown, rusty powder, which is quite characteristic of the disease (figure 11). When first forming, the spot appears to be a darker green. Later, on certain varieties of beans, a distinct yellow border surrounds the pustule. But one or two spots may appear

on the leaf, or there may be so many that the leaf withers and dies. On the stem and pods, the spots occur less commonly, and never in such large numbers.

The cause of the rust of beans is the fungous pathogene *Uromyces appendiculatus*.

According to the Virginia Agricultural Experiment Station, the Red Kidney and the White Marrow varieties are very resistant to the disease, while the Navy pea is susceptible. The climatic conditions of New York State, however, which naturally hold the disease in check, make it unnecessary for the growers to use only rust-resistant varieties or to search for methods of control for the disease.

PHOTO BY H. H. WHETZEL

FIGURE 12. THE SCLEROTINIA ROT ON PODS AND STEMS OF A BEAN PLANT

MINOR DISEASES OF THE BEAN

Sclerotinia rot

The Sclerotinia rot is a disease of the bean that occurs rather infrequently in New York State. When it appears, however, it may be very severe. The conditions favorable to its development are continuous damp weather and shade. These conditions are not, as a rule, found in the average bean field. Low areas and weeds, however, are very conducive to the appearance of the rot.

The fungus (*Sclerotinia libertiana*) which causes the disease attacks the stem and the pods of the bean plant, and produces a soft, brown rot. Usually a cottony growth of the fungus occurs on the diseased plant over the rotted areas (figure 12). Small, hard bodies, 1/8 to 1/4 inch in diameter, known as *sclerotia*, are found in the cottony growth and on the diseased plants. If there are weeds present in the field in which the Sclerotinia rot occurs, many of them will also develop similar symptoms of the disease.

The Sclerotinia rot can be very easily prevented. The disease will never cause more than the slightest damage on well-drained fields which

are thoroly cultivated. The entire elimination of weeds is essential.

Sun scald

The sun scald of beans is a disease of no consequence on the dry-shell varieties. On the other hand, the injury on the snap, or garden, varieties, due to the disfiguration of the pods, reaches an economic importance at times.

In some instances it is very difficult to distinguish the sun scald from the bacterial blight. Reddish to brown, irregular sunken spots occur on the exposed surface of the pods (figure 13). These spots vary somewhat with the different varieties. On field beans such as the White Marrow, the spots appear just over the seed, are seldom sunken, and are light brown in color. On the Refugee Green Pod, sun-scald spots are reddish, sunken, and very irregular in appearance. On this variety it usually occurs after the field has been picked once, and the bean foliage has been thrown back, exposing the young pods.

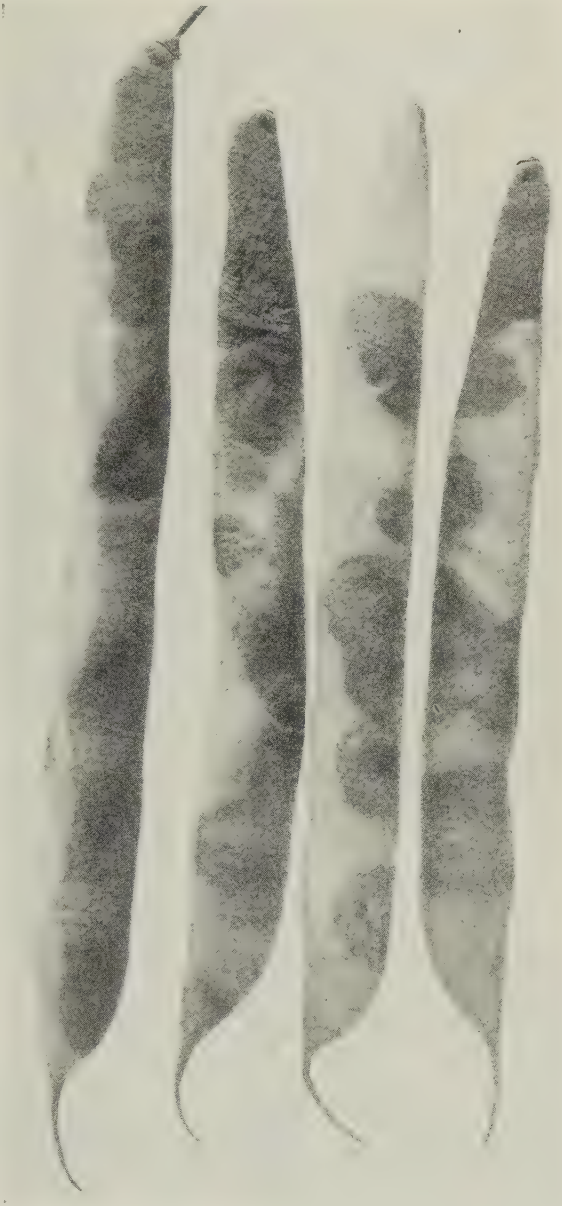


FIGURE 13. SUN SCALD ON BEAN PODS OF THE WHITE KIDNEY VARIETY

INSECT AND OTHER PESTS OF BEANS IN NEW YORK

C. R. CROSBY

THE SEED CORN MAGGOT

(*Hylemyia cilicrura* Rondani)

In years of excessive rainfall during May and June bean growers are likely to experience heavy losses from the destruction of the germinating seed by maggots. It often happens that the seed in whole fields is so badly injured that the crop has to be abandoned and the land refitted for some other crops. The flies of the seed corn maggot are very similar to those of the cabbage root-maggot. The spring brood of flies appears in May. They are attracted to newly plowed land, where they deposit their

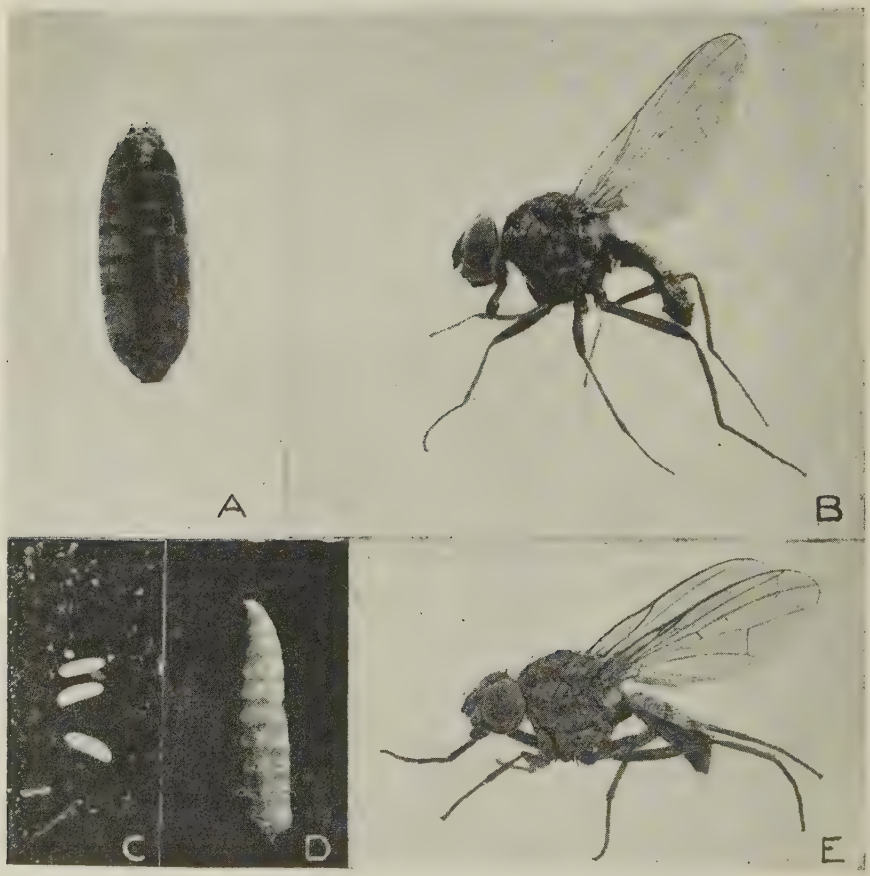


FIGURE 14. THE SEED CORN MAGGOT

A, Puparium, × 8. *B*, Parent fly, male, × 10. *C*, Eggs, on dirt, × 6. *D*, Larva, × 5. *E*, Parent fly, female, × 10.

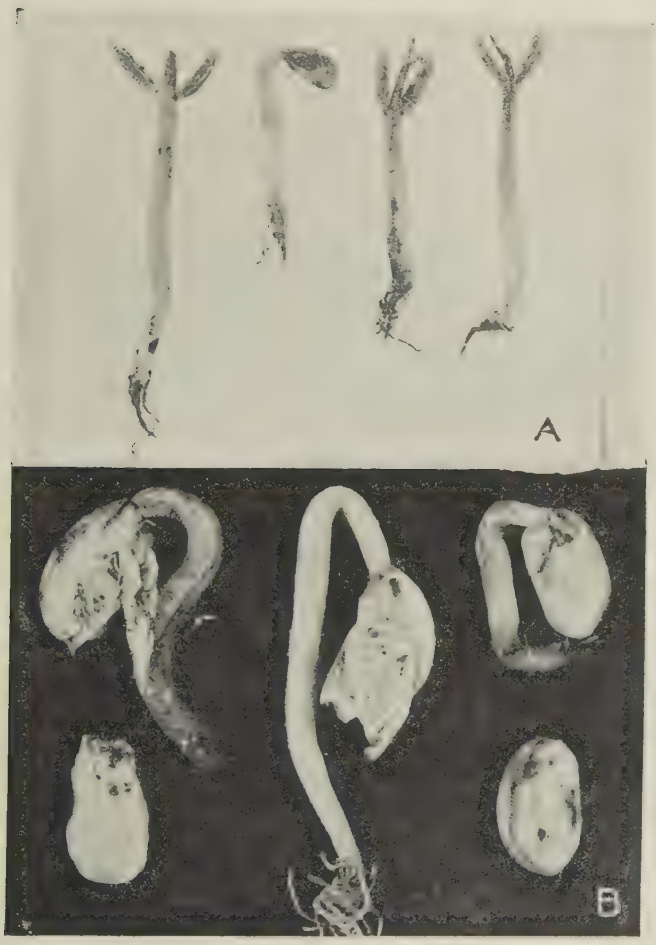


Figure 15. Injury by the seed corn maggot

A, Types of injury in bean seedlings. *B*, Injured bean plants, known as snakeheads, showing the result of feeding by the seed corn maggot

eggs in the soil. They prefer moist conditions for egg-laying, and the eggs are usually placed near decaying vegetation. Soil containing the decaying roots of clover or alfalfa is especially attractive to the flies for egg-laying. The eggs hatch in from two to four days into small white maggots. These make their way thru the soil in search of food. They may subsist on decaying vegetable matter or germinating seeds. The maggots become full-grown in from nine to twelve days, and then transform to the puparium state in the soil. The flies emerge about two weeks later. There are two main broods of the flies annually; the first appears the latter part of May and the second in July.

If beans are planted in infested soil, the maggots attack the germinating seeds, feeding on the two seed leaves and often destroying the small bud between the two halves of the seed bean. If this bud is destroyed, the plant comes up in a deformed condition and is known as a *snakehead* or a *baldhead*. Plants injured in this way never produce a crop of beans.

Control

No practical way has been found to treat the seed or the soil with chemicals to prevent injury by the seed corn maggot. Much injury may be avoided, however, by adopting certain practices. The flies are attracted to freshly plowed ground for egg-laying. If the fields intended for beans are plowed and fitted in April or early May before the flies become abundant, the top soil will be dried out when they appear and the number of eggs deposited will be greatly reduced. Fields fertilized with barnyard manure just before planting are likely to harbor many maggots. It is, therefore, better to apply the manure to some other crop in the rotation and to use commercial fertilizer on the beans.

If the beans are planted shallow so that they come up quickly, serious maggot injury may be avoided. If the beans are planted with a drill, there is danger of getting them too deep in the soil. It is better to use a bean planter.

Much may be done to prevent injury by choosing a favorable time for planting. For the earlier maturing varieties it is sometimes a good plan to delay planting during periods of wet weather, but of course beans must be planted in time for them to mature before frost. In western New York the maggots are usually most abundant in the soil during the last week in May and the first week in June. If the weather is cold and wet, planting at this time should be avoided.

THE FIELD GRAY SLUG

(*Agriolimax agrestis* L.)

The field gray slug is not an insect. It is a mollusk belonging to the same group of animals as do the snails proper (figure 16). This animal

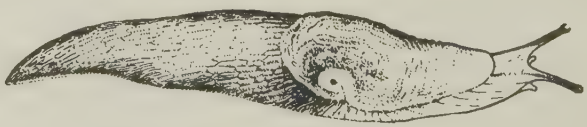


FIGURE 16. THE FIELD GRAY SLUG

is often very destructive to field beans. It is of European origin, but at the present time it may be found in many parts of the United States. It is present in many places in the bean-growing section of western New York, but it is not found in serious numbers in all localities where beans

are grown. This pest has been known to destroy 70 per cent of the beans in some fields, and in one case observed, the slugs were so numerous in three acres of a ten-acre field that not a trace of a plant was left above ground.

Hosts and food supplies

In addition to the bean, the field gray slug is especially injurious to peas, corn, cabbage, lettuce, potatoes, tomatoes, carrots, radishes, beets, and strawberries. It also has been known to feed on many weeds and flowers, as well as on earthworms, sowbugs, soap, and sponge cake. This slug will also feed on the roots of grass in pasture land and in lawns.

Nature of injury of slugs to beans

Small slugs feed on the tender leaves of beans, and often produce a skeletonized condition (figure 17), as they do not eat thru the veins.

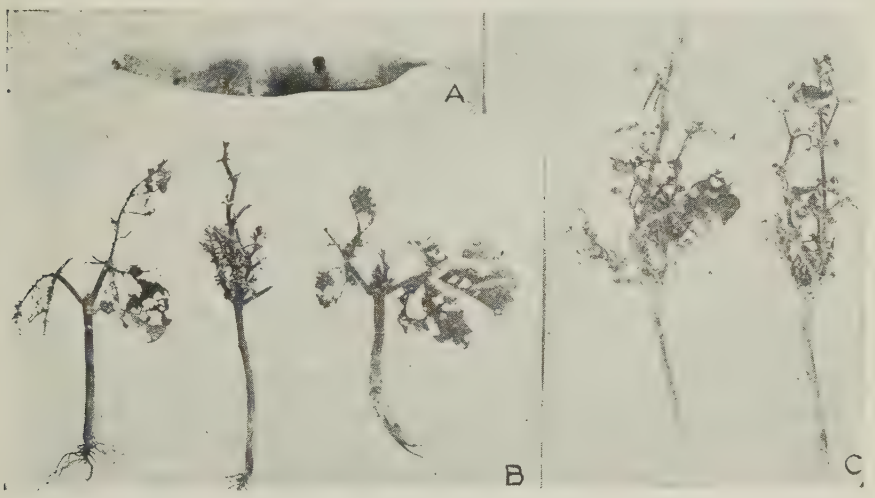


FIGURE 17. INJURIES CAUSED BY THE FIELD GRAY SLUG

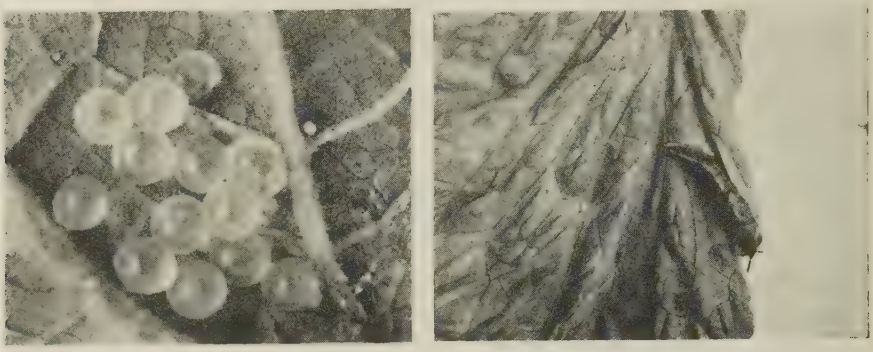
A, A bean pod showing a hole made by the slug in feeding. *B*, Bean plants injured by slugs (photographed in midsummer). *C*, Bean plants that were injured by slugs soon after they appeared above ground (photographed at harvest time)

Older slugs devour entire leaves, and sometimes also feed on the pods. The developing bud is especially attractive, and when this is destroyed the plant produces a useless growth of small leaves, and never matures pods.

Life history of the field gray slug

The field gray slug may pass the winter either in the egg stage or as a mature slug, beneath any kind of protective covering in and around fields and gardens. If it hibernates as a slug, it comes out of its hiding place in April or May, and deposits its round, jellylike eggs in clusters

of from five to fifty, around grass roots or in crevices of the ground Both the overwintering eggs and those that are deposited in the spring hatch during May, and the small animals are then ready to feed on beans



A B

FIGURE 18. EGGS AND ADULT OF THE FIELD GRAY SLUG

A, Eggs deposited on a leaf by a field gray slug, × 5. *B*, The field gray slug on a cabbage leaf, slightly reduced

or other crops. They are mature by fall, and again eggs are deposited or the slug goes into winter quarters. There is only one generation a year in New York.

Habits of the field gray slug

During the day, slugs conceal themselves by crawling into the ground or beneath boards, rubbish, or weeds; but at night they come out and move about in search of food. Their nightly journeys are recorded by a trail of glistening slime that is left wherever the animal goes, and at times young slugs have been known to lower themselves from plants to the ground by a thread of this material. This pest thrives best under moist conditions, and when the weather is dry, it remains underground and does not come up to feed. Slugs have the power of contracting their bodies until they are only about one-half their actual length when they are crawling. When contracted, the long, stalked tentacles, on the ends of which the eyes are borne, may be entirely withdrawn into the body.

Control

Slugs may be kept from field beans by a spray of bordeaux mixture containing 4 pounds of copper sulfate (blue vitriol) and 5 pounds of hydrated lime in 50 gallons of water. Bordeaux is very distasteful to slugs, and they will not feed on foliage that has been well covered with this material. This spray should be applied thoroly, early in July, when the bean plants are still small and soon after the slugs begin their destructive work. A potato sprayer having three nozzles to a row is most

satisfactory. In an arrangement of this kind, a central nozzle coats the tops of the leaves, and two nozzles on arms near the ground cover the under sides of the leaves (figure 19).

FIGURE 19. SPRAYING MACHINE USED IN EXPERIMENTS FOR THE CONTROL OF FLEA BEETLES ON BEANS

In very severe infestations, a poison bait made by mixing 1 part, by weight, of calcium arsenate with 16 parts of chopped lettuce or clover should be used in connection with the spray of bordeaux mixture just mentioned. The calcium arsenate should be mixed thoroly with the lettuce or clover, and then moistened with water until the bait clings together without being sloppy. This may be scattered broadcast across the field between the rows of beans. Professor Lovett, of Oregon, has obtained excellent results against slugs by the combination of the bordeaux spray and this poison bait. The slugs repelled from the plants by the bordeaux were killed when they fed on the bait.

Slugs may also be killed if heavily dusted with lime. This material irritates the skin and causes the animals to give off slime in such large quantities that they become weakened. However, it may be necessary to apply several doses, at intervals, before the animals are all killed. This material may be applied to slugs crawling on the ground, or to bean plants, by means of a hand duster, or, on a small scale, by shaking the powder thru a cheese-cloth bag.

A control measure important in all slug infestations is to keep the edges of fields and gardens clean. Many slugs pass the winter concealed around the roots of grass and weeds, and many infestations start from these places in the spring. If manure is spread in the fall on sod land that has been infested with slugs, beans planted in these fields the following year will often be seriously damaged. The manure gives the animals protection from the cold, and they apparently continue to breed here thruout the winter.

In small gardens, slugs may be collected as they come above ground at dusk, or later in the evening by means of a flashlight. They may also be trapped by means of shingles, cull potatoes, lettuce, or cabbage leaves scattered about infested places. After feeding during the night, many slugs will, at daybreak crawl under objects of this kind placed on the ground. They may then be gathered and destroyed.

FLEA BEETLES

Pale-Striped Flea Beetle (*Systena taeniata* Say)

Red-Headed Flea Beetle (*Systena frontalis* Fabricius)

Two species of flea beetles often attack beans in New York. The pale-striped flea beetle is present in the fields from June till September, but the red-headed species does not appear in numbers till July. The injury to the young plants may be serious, especially if they are making a slow growth. The leaves become riddled with holes, turn yellow, and die.

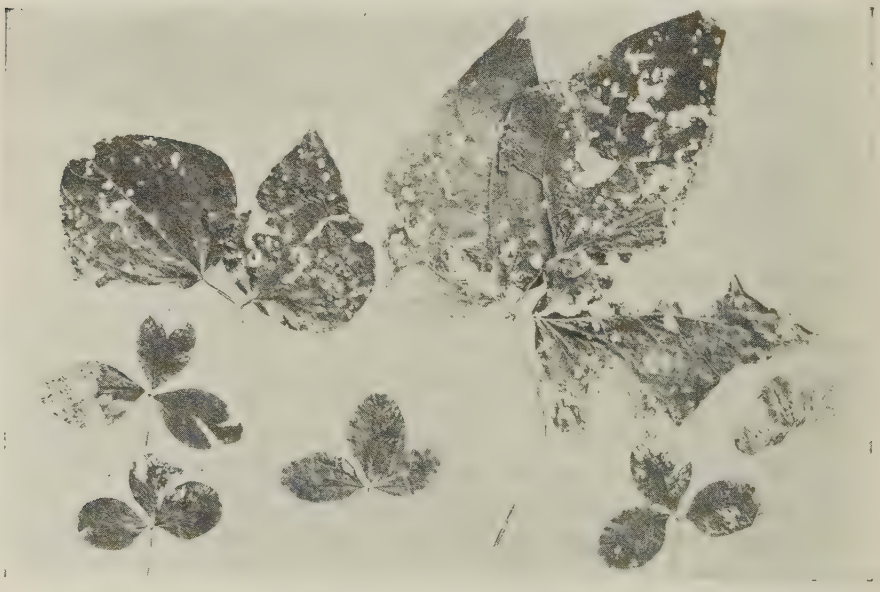


FIGURE 20. BEAN AND CLOVER LEAVES INJURED BY THE RED-HEADED FLEA BEETLE

Control

Flea-beetle injury to the young plants can be largely prevented by spraying with 1½ pounds of lead arsenate in 50 gallons of 4–4–50 bordeaux mixture or by dusting with one part of calcium arsenate in eight parts of hydrated lime. When the flea beetles become troublesome later in the season, the insecticides recommended for the control of the Mexican bean beetle (page 38) may be used.

THE GREEN CLOVER WORM

(*Plathypena scabra* Fabricius)

At intervals of several years there occur outbreaks of a slender, pale green caterpillar which riddles the bean foliage with large irregular holes and may even entirely defoliate the plants. The larvae of the green clover worm are destructive during July and August. The last serious outbreak of this insect was in 1919.

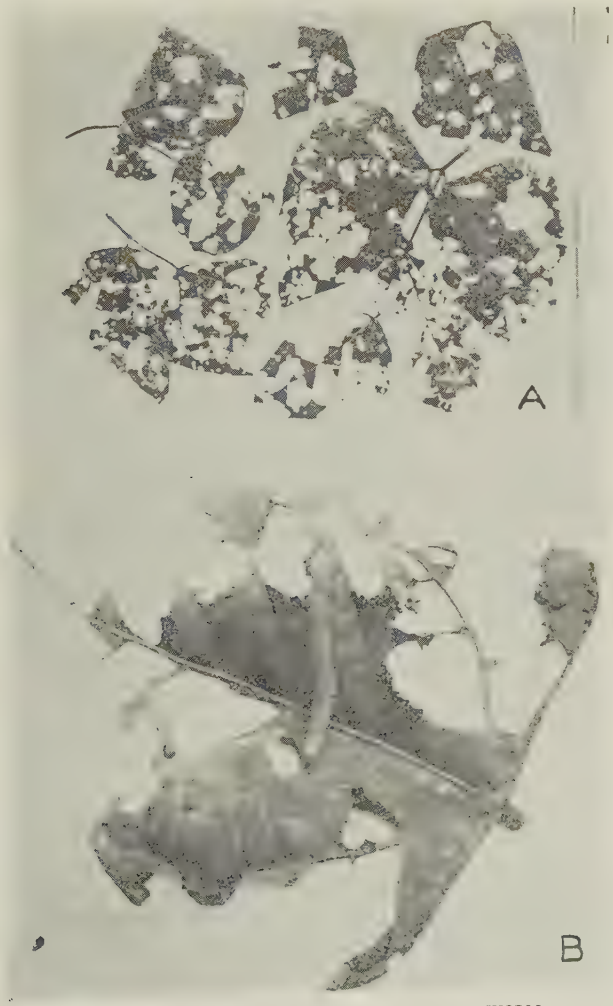


FIGURE 21. WORK OF THE GREEN CLOVER WORM

A, Bean leaves injured by feeding of the worm, reduced
B, Larva feeding on a bean leaf, slightly enlarged

Control

On field beans the larvae can be readily controlled by applying any of the insecticides recommended for the control of the Mexican bean beetle (page 37). On podded string beans, where it is unsafe to apply an arsenical, the larvae can be killed by spraying thoroly with nicotine sulfate, 1 pint in 100 gallons of water in which 5 or 6 pounds of soap has been dissolved.

THE BEAN WEEVIL

(*Bruchus obtectus* Say)

Altho a serious pest in the South, the bean weevil rarely causes loss in commercial plantings in New York. Beans grown in gardens, however, may become heavily infested. Infestation by the bean weevil takes place in the field. The weevils lay their eggs in the pod, either thru a small hole made by the female or thru openings caused by drying and splitting of the pods. The grubs enter the bean when they are very small and become full-grown in the bean itself, and there transform to the adult, or weevil. In the case of the bean weevil the adults may emerge from the beans in storage, and may lay eggs among the dry beans, causing a secondary infestation. With the pea weevil, infestation occurs only in the field.

FIGURE 22. THE BEAN WEEVIL

To destroy the weevils, the beans should be fumigated with carbon bisulfide in the fall. Place the beans in a very tight box or tight barrel. A cracker barrel or a sugar barrel is not tight enough. Use 1 ounce of carbon bisulfide to each bushel of beans, provided the beans nearly fill the receptacle. Place the carbon bisulfide in a shallow dish, such as a pie tin, on top of the beans, and cover the box or the barrel very tightly. Let fumigation continue for from twenty-four to thirty-six hours. To be effective, the work should be done where the temperature is at least 70° F. Carbon bisulfide is very inflammable and should not be brought near a fire. Do not smoke while fumigating the beans.

Beans containing living weevils should never be used for seed, because it is in this way that most of the insects gain access to the field. Even infested beans that have been fumigated should not be used for seed, for the percentage of germination will be low and those that do germinate will produce weak unthrifty plants.

MEXICAN BEAN BEETLE

(*Epilachna corrupta* Mulsant)

For many years the Mexican bean beetle has been known as a serious pest in the foothills of the Rocky Mountains from Wyoming southward into Mexico. In 1920, a small area in northern Alabama was found to be infested. From this new center the insect has spread rapidly northward and eastward until in 1927 it appeared in southwestern New York. It is now widely distributed throughout the State, and is especially injurious on Long Island.

The Mexican bean beetle passes the winter in the adult condition, often at a considerable distance from the bean field. The hibernating beetles can be found under piles of rubbish, in the drifted piles of leaves along fence rows, under the fallen leaves at the edges of woodlots, and in similar situations. The beetle is about 1/3 inch in length, oval in outline, strongly convex above, and pale yellowish to brownish in color. The eyes are black, and each wing cover is marked with eight small black spots arranged in three transverse rows. The beetles appear in the bean fields about the time the plants put out their first leaves. They feed on the foliage, mostly from the underside, eating holes in the leaves. The eggs, which are about 1/20 inch in length, oval in shape, and yellow in color, are deposited on end, in clusters of from 40 to 60, on the underside of the leaves. They hatch in from six days to two weeks, depending on the temperature. The larvae feed on the underside of the leaves, leaving the upper epidermis and a network of tissue and veins. The injured leaves dry up, and in severe cases the plant is killed. The larva passes through four stages in the course of its development and becomes full-grown in from three to five weeks. It is then about 2/5 inch in length, light yellow in color, and clothed with stout branched spines. When mature, it attaches the tip of its body to the leaf and transforms into a yellow pupa about 1/3 inch in length. The pupal period occupies about a week. The entire life cycle is completed in from four to seven weeks, depending on the temperature. Under New York conditions two generations develop annually.

Control

Arsenical poisons may be used for the control of the Mexican bean beetle early in the season, but they should not be used on string beans or lima beans after the pods begin to form. Magnesium arsenate is the most satisfactory arsenical for this purpose; if it cannot be obtained, calcium arsenate may be substituted although it is somewhat more likely to injure the foliage. These arsenicals may be applied either as a spray or dust. Insecticides are effective against the bean beetle only when applied to the undersurface of the leaves.

For dry beans and string beans up to blossoming time

Spray formulas

Use 100 gallons per acre.

Magnesium arsenate	3 pounds
Water	100 gallons

Add either 3 pounds of caseine spreader, or 3 pounds of flour paste, or a mixture of 3 quarts of skimmilk and ½ pound of hydrated lime.

If magnesium arsenate cannot be obtained, use the following:

Calcium arsenate	3 pounds
Hydrated lime	9 pounds
Water	100 gallons

Dust formulas

Use 30 pounds per acre.

Magnesium arsenate	20 pounds
Hydrated lime	80 pounds

If magnesium arsenate cannot be obtained, use the following:

Calcium arsenate	15 pounds
Hydrated lime	85 pounds

The first treatment for the beetle should be made when the eggs begin to hatch or sooner if the beetles are abundant and are causing injury. Usually two applications of the spray or three treatments with dust are required.

After the pods begin to form neither arsenicals nor fluorine compounds should be used on string beans nor on lima beans. If it is necessary to fight the insect at this time, dust containing ½ of 1 per cent of rotenone should be used. It is not advisable to attempt to combine rotenone with bordeaux mixture because in this combination the effectiveness of the insecticide is greatly reduced.

Unremitting Warfare

MAN'S efforts in the struggle for a living, are constantly directed against insects and diseases. Much of the warfare is waged against these twin enemies where they affect his food supply.

Science furnishes the ammunition of facts; education makes use of that ammunition. The bulletins issued by the Extension Service of the College of Agriculture are part of the educational campaign.

The College has other bulletins on insects, and on vegetable crops. Some of these are:

Control of diseases and insect pests of potatoes in up-state New York (E 238) *Barrus and Crosby*

The control of diseases and insects affecting vegetable crops (E 206) *Crosby and Chupp*

Commercial varieties of vegetables for New York State (E 176) *Schneck*

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